# Comparison of the Warn-on-Forecast System and a High Resolution Rapid Refresh Time-Lagged Ensemble for Forecasting Short-Term Convective Evolution

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## Motivation and Datasets

NSSL's **Warn-on-Forecast System (WoFS)** is a convection-allowing model (CAM) ensemble run experimentally in real-time for select cases, primarily in the spring during NOAA's HWT Spring Forecasting Experiment (SFE).

- WoFS initial and lateral boundary conditions are provided by ESRL-GSD's experimental HRRRE.
- Cycled analyses are generated every 15 min via GSI-EnKF based data assimilation of radar reflectivity and radial velocity, satellite data, and mesonet+ASOS surface observations.
- Forecasts generated from cycled analyses run every 30 min out to a maximum lead time of 6 hours, and are targeted at space/time scales from watches to warnings.
- Grid spacing is 3-km; covers a ~900x900 km domain selected daily to cover a relevant forecast problem.
- Has 18 forecast members with a multi-physics (PBL, radiation) configuration.
- Real-time and archived WoFS output is available at: **wof.nssl.noaa.gov/realtime**

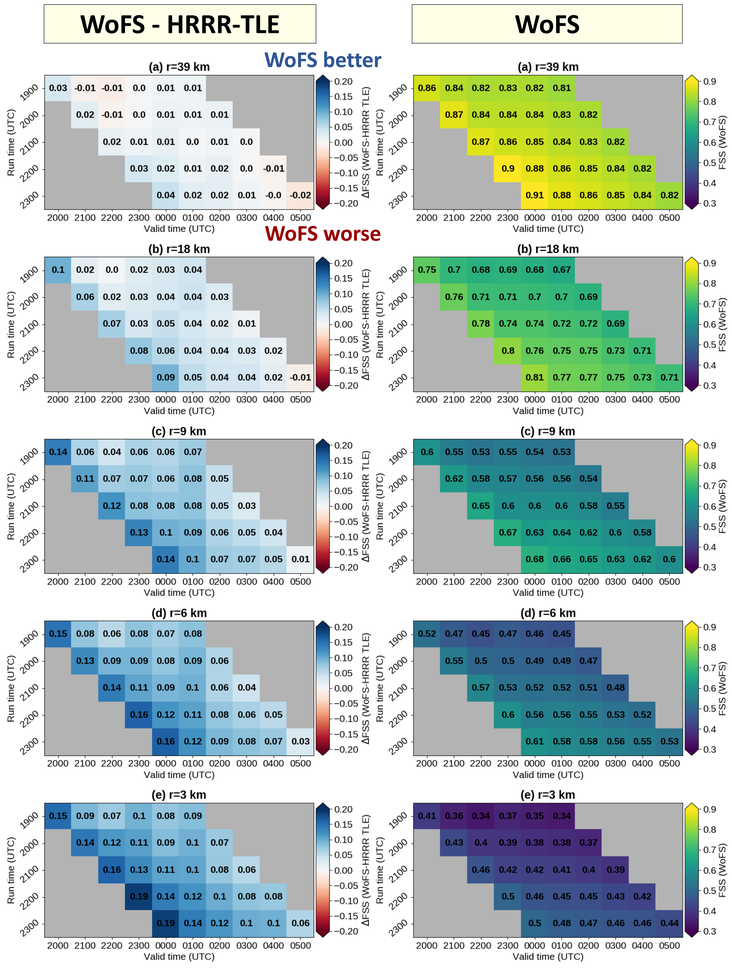
In this study, we will compare WoFS output from Spring 2019 to an ad-hoc **HRRR Time-Lag Ensemble (HRRR-TLE)**, which is constructed by aggregating the four most recent hourly HRRRv3 runs. Because the HRRRv3 is a fully operational CAM and already runs hourly, the HRRR-TLE is cheap to process and display operationally today. This makes it a good baseline short-range CAM ensemble to demonstrate the value of WoFS against. HRRRv3 uses a RAP background, GSI-based hybrid DA, and a latent-heating technique for radar DA.

## Forecast Skill Comparison

Verification is performed on 23 cases from Spring 2019 (4/30-5/3, 5/6-5/10, 5/13-5/17, 5/20-5/25, 5/28-5/30). For each case, hourly runs from 1900-2300 UTC are evaluated.

Fractions Skill Score (FSS) is computed for bias-corrected 40-dBZ neighborhood maximum ensemble probabilities (NMEPs) hourly at lead times of 1-6 hours. This should capture skill in forecasting the overall convective evolution and storm placement. MRMS reflectivity is used for observations.

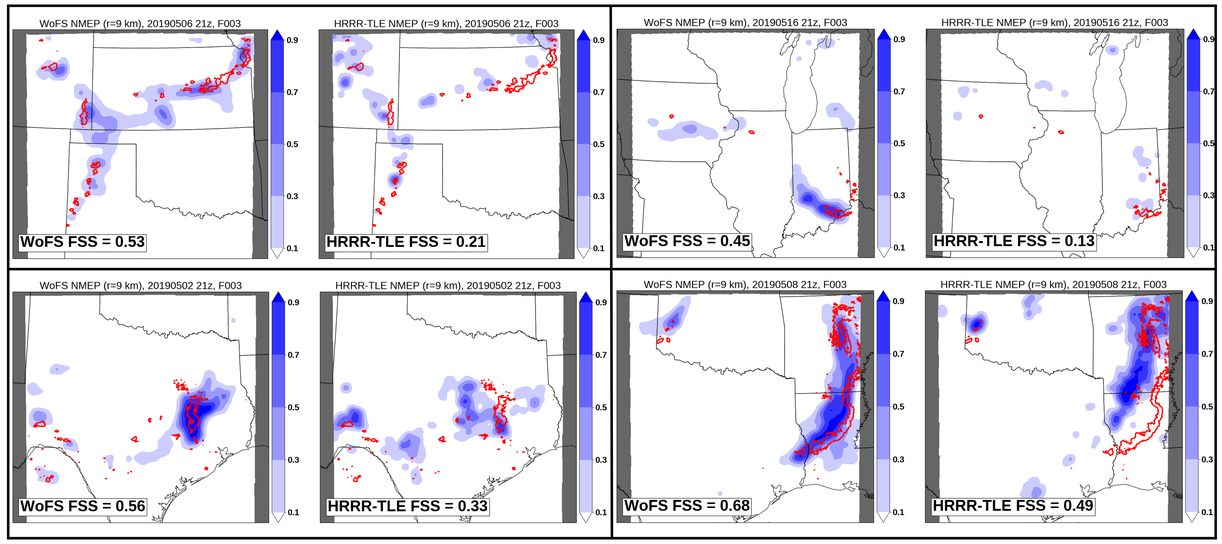
- At spatial scales traditionally used for the next-day problem (r ~ 40 km), WoFS offers little added value over HRRR-TLE.
- At smaller scales, increasing added value is seen for WoFS, particularly for r ≤ 9 km.
- WoFS's advantage is most pronounced at short lead times, likely due to its more sophisticated and frequent radar DA.
- WoFS also shows an increasing advantage over HRRR-TLE at later initialization times in the diurnal cycle (e.g., 2200-2300 UTC), presumably after convective initiation has rendered radar DA more impactful, on average.



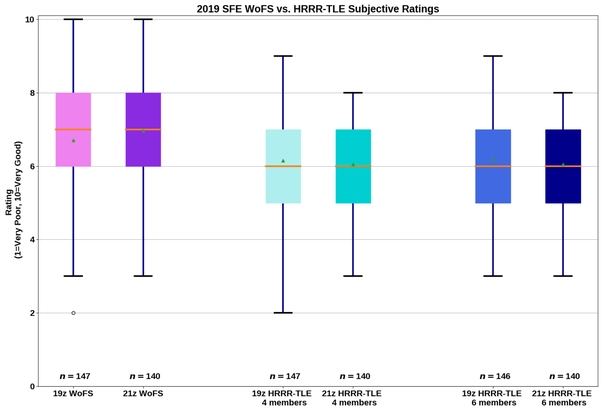

## Notable Cases and Subjective Ratings

**In which cases did WoFS add the most value over HRRR-TLE?**

- The 23 cases comprising the verification dataset span diverse regions, convective modes, and diurnal timing.
- It is useful to identify cases which WoFS demonstrated the most added value for over HRRR-TLE.




- For 3-h forecasts valid at 0000 UTC, the four cases with the largest ΔFSS for r=9 km NMEPs between WoFS and HRRR-TLE are shown above, with MRMS 40-dBZ composite reflectivity overlaid as a red contour. (Among all 23 cases, ΔFSS ranged from -0.06 to +0.32, with a median of +0.09).
- A common theme from these large-ΔFSS cases is the presence of a linear convective system that is in the process of growing upscale and/or bowing out. HRRR-TLE has a tendency to underforecast convective coverage, organization, and propagation speed for the linear complexes in these cases, compared to WoFS.
- Linear convective systems do also exist in some cases with small ΔFSS, so further investigation is needed.




**Subjective ratings from SFE2019**

- Each day in SFE2019, participants rated two cycles (1900, 2100 UTC) of the previous day's WoFS forecasts subjectively on a 1-10 scale. They also rated equivalent forecasts from 4- and 6-member HRRR-TLEs shown alongside the WoFS output.
- The main products evaluated were 1-h and 4-h max updraft helicity NMEPs (with LSRs overlaid).
- *Although the version of WoFS evaluated in real-time had subtle bugs in its ICs* (whereas the version verified objectively in this study addressed these bugs), it was still rated higher than either HRRR-TLE variant, in the aggregate.
- WoFS received some "10" ratings!

## Acknowledgements

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